

CLEAN COAL TECHNOLOGIES, CLEAN AIR LEGISLATION,  
AND NATIONAL ENERGY STRATEGY

by

C. Lowell Miller, Ph.D.  
Associate Deputy Assistant Secretary for Clean Coal  
Office of Fossil Energy (FE-22)  
U.S. Department of Energy  
Washington, D.C., 20585

## Introduction

Over the last year or two, several new phrases have become part of our lexicon, and have become so well known that they are now "household words"; included are phrases like:

- Acid rain,
- Ozone depletion, and
- Global warming.

These words all conjur up a frightening image of withering trees, dying lakes, sunburn, rising oceans, and flooded coasts. As a response, however, in 1989 the Bush Administration strove to familiarize the American public with two more phrases; these were:

- The Clean Air Act Amendments of 1989, and
- National Energy Strategy.

If the job is done right, the image that these words will conjur up will be reduced pollution, environmental protection, and a reliable supply of energy at an affordable price. That's where the Clean Coal Technology (CCT) Program comes in, because the CCT Program is the single most potent means at our disposal with which to overcome the global dilemma of how to use our abundant fossil fuels — not just America's, but indeed the world's — without simultaneously impairing the very quality of life we are working to improve with readily available electrical and other forms of energy.

There is no point in pretending that coal is what it is not, nor that it is not what it is. Coal is naturally endowed with the elements and minerals of the living organisms that define its primordial origins, and that means the carbon for which it is valued. But, to some degree, it also must mean sulfur, and nitrogen, and incombustible impurities. It is an incontrovertible fact that the uncontrolled burning of coal will release into the environment carbon dioxide (CO<sub>2</sub>), sulfur dioxide (SO<sub>2</sub>), oxides of nitrogen (NO<sub>x</sub>), particulate matter, and ash.

It is the business of the CCT Program to develop the means of burning this coal with attendant minimal emissions of these undesirable pollutants; we know that there can never be none. So, if not literally "clean" coal, then certainly we mean "cleaner" coal, and it is in this sense that the Program uses the shorthand term, Clean Coal Technology.

### **What Are Clean Coal Technologies?**

Now, having said that, what are Clean Coal **Technologies**? When we refer to CCTs, we mean advanced coal-based systems that can offer significant benefits when used to generate power, control pollution, or to convert coal into other alternative energy products.

For electric utilities, the characteristics of these technologies, including such attributes as higher thermal efficiency, modular construction, improved environmental performance, fuel flexibility, and repowering capability, will help them adapt to the decade of the 90's — a time of difficult and even conflicting pressures from regulatory reform, uncertain growth in power demand, environmental concerns, and increasing competition from independent power producers and cogenerators.

With regard to pollution control, CCTs have the ability to produce less, or to directly remove from the combustion process, SO<sub>2</sub> and NO<sub>x</sub> acid rain precursors, and to reduce the amount of CO<sub>2</sub> generated by coal combustion. The types and quantities of pollutants removed will, of course, be a function of the specific CCT under consideration. In fact, some CCTs (e.g., pressurized fluidized bed combustion [PFBC] and integrated gasification combined cycle [IGCC]) even have the ability to remove SO<sub>2</sub> and NO<sub>x</sub> while at the same time increasing the power output of the facility itself from 50-150 percent. Table 1 lists the environmental performance of CCTs as compared to conventional (uncontrolled) pulverized coal-fired power plants.

Finally, CCTs can afford us the opportunity to produce coal-derived liquid fuels to replace oil and gas in numerous important applications. This capability could permit coal to play a much greater role in providing energy to the industrial, commercial, and transportation sectors.

### **The Projects That Comprise the CCT Program**

On December 19, 1985, Congress passed Pub. L. No. 99-190, *An Act Making Appropriations for the Department of the Interior and Related Agencies for the Fiscal Year Ending September 30, 1986, and for Other Purposes*. Included in this Act were provisions for funds to conduct cost-shared, clean coal technology, projects for constructing and operating facilities demonstrating the feasibility of future commercial clean coal applications.

## ENVIRONMENTAL PERFORMANCE OF CLEAN COAL TECHNOLOGIES RELATIVE TO CONVENTIONAL COAL-FIRED POWER PLANTS

Technology	SO <sub>2</sub> Reduction	NO <sub>x</sub> Emissions	Waste Characteristics
Coal Cleaning:	10 - 30%	No change.	Solids disposal.
Flue Gas Desulfurization:	90+ %	No change.	Sludge disposal.
Advanced Flue Gas Cleaning	90+ %	Large reduction.	Usable byproduct.
Lime. Inj. Ms. Burner (LIMB):	50 - 60 %	Moderate reduction.	Dry pwdr. ok for landfill.
Slagging Combustor:	50 - 90 %	Moderate reduction.	Dry pwdr. ok for landfill.
Gas Reburning:	10 - 20 %	Moderate reduction.	None produced.
In-duct Sorbent Injection:	50 - 70 %	No change.	Dry pwdr. ok for landfill.
Advanced Coal Cleaning:	30 - 90 %	No change.	Solids disposal.
Int. Gas. Cmb. Cycle (IGCC):	95 - 99 %	Moderate reduction.	Slag, S, min. addl solids
Pressurized FBC:	90 - 95 %	Moderate reduction.	Dry gran. nontox. solids
Atmospheric FBC:	85 - 90 %	Moderate reduction.	Dry gran. nontox. solids

This first solicitation was open to all market applications of CCTs that applied to any segment of the United States coal resource base; the solicitation also encompassed both "new" and "retrofit" applications. DOE issued a Program Opportunity Notice (PON) on February 17, 1986, and received of 51 proposals by the April 18, 1986, deadline.

The outcome was the selection, on July 25, 1986, of nine initial projects for negotiation of Cooperative Agreements, and the identification of 14 alternate projects to be considered should negotiations not be successfully completed with any of the initial candidates. As of this writing, 8 of the alternate projects eventually entered into negotiations. Seven Cooperative agreements have now been executed, while three additional projects are in various stages of negotiation. These ten CCT-I projects now in the Program, and their locations, are shown in Figure 1.

While CCT-I was directed at demonstrating technologies that could, through increased efficiency and flexibility, increase the role of coal as an energy option, CCT-II was more focused and directed specifically on demonstrating technologies that can address the environmental aspects of coal use associated with the issue of acid rain. The objectives were derived principally from the efforts and results of the Special Envoys on Acid Rain. (In March 1985, the President appointed Drew Lewis to be the United States Special Envoy on Acid Rain, and, at the same time, Prime Minister of Canada Brian Mulroney appointed William Davis as the Canadian Special Envoy. The Special Envoys were charged with the responsibility to assess the international environmental problems associated with transboundary air pollution, and then recommend actions that would solve them.)

In January 1986, the Envoys presented their findings, including their recommendation that the United States initiate a 5-year, \$5-billion, program for commercial demonstration of control technology projects recommended by industry and jointly funded by government and industry. In March 1986, the President endorsed the Special Envoys' recommendations, hence setting in motion the development of an expanded CCT Program that would build on the CCT-I effort, reflect ongoing State and privately funded initiatives, and be fashioned as fully as practicable from the guidelines recommended by the Special Envoys.

Accordingly, a second solicitation (CCT-II) was prepared and released on February 22, 1988, and, on September 28, 1988, 16 additional projects were selected for the Program; as of this writing, 9 of the projects have consummated Cooperative Agreements, while one project has withdrawn. The remaining 15 CCT-II projects and their locations are shown in Figure 2.

# Clean Coal Technology Round #1

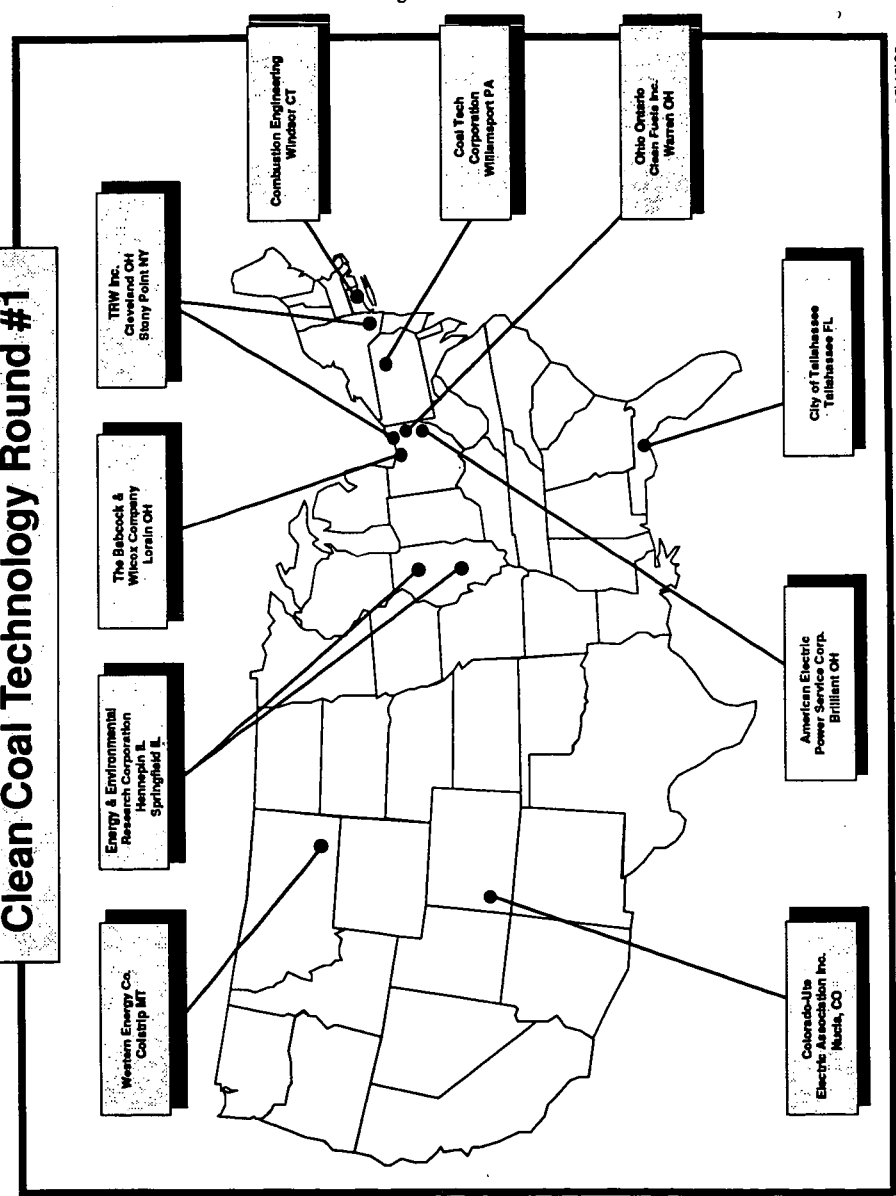
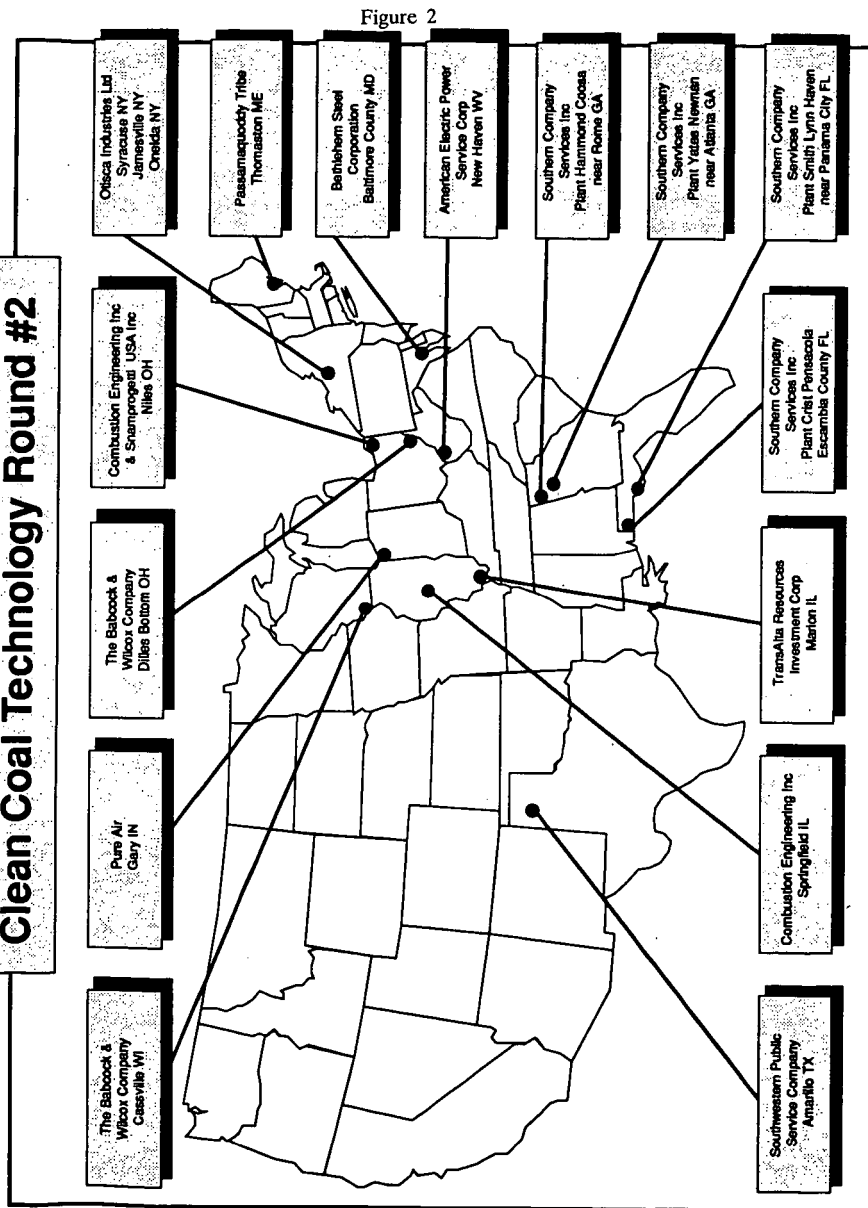


Figure 1

03/13/90

# Clean Coal Technology Round #2



03/13/90

The cost-shared CCT-II projects will demonstrate technologies that are more cost-effective than existing technologies, and are capable of achieving significant reductions in SO<sub>2</sub> and/or NO<sub>x</sub> emissions from existing coal burning facilities, particularly those that contribute to transboundary and interstate pollution. Of the 15 projects, 12 technologies can be retrofitted to existing coal-burning plants, and three can be used to repower existing facilities. Analyses show that the generic technologies represented by the CCT-I and -II projects, if adopted by much of the market to which they are applicable, would result in significant National reductions in SO<sub>2</sub> and NO<sub>x</sub> emissions by the year 2010.

Language in Pub. L. No. 100-446, *Making Appropriations for the Department of the Interior and Related Agencies for the Fiscal Year Ending September 30, 1989, and for Other Purposes*, established the schedule for the third CCT Program solicitation (CCT-III). The PON was issued on May 1, 1989, and, on December 21, 1989, 13 additional projects were selected for the Program. Seven of the projects are advanced retrofit pollution control technologies, three are utility repowering technologies, and three are new coal-based fuel form technologies. The CCT-III projects and their locations are shown in Figure 3.

Regardless of the specific CCT technology, the Program can contribute to improving the world in which we live, as discussed below. As Secretary of Energy Watkins has noted, environmental issues transcend national, socioeconomic, ethnic, and cultural boundaries. We must curb emissions of pollutants that contribute to acid rain and urban smog. The past decade has also seen rising concerns over the potential for global climatic change, although, at present, our science is not conclusive regarding this threat. As a result, there is great uncertainty regarding the possible consequences of these changes.

## **Coal Use and Global Warming**

One of the critical environmental issues that has gained National attention is the possibility of global climatic change in response to increases in atmospheric concentrations of "greenhouse gases" — most notably carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), and chlorofluorocarbons (CFCs). The atmospheric concentration of CO<sub>2</sub> increased 9.5 percent between 1960 and 1986. It generally is recognized that combustion of fossil fuels is the primary contributor, although global deforestation is an important contributing factor. In 1986, the United States contributed 22 percent of the global CO<sub>2</sub> emissions from burning fossil fuels; of these 22 percent, electric power generation contributed 35 percent, transportation 30 percent, industrial sources 24 percent, and the remaining 11 percent was contributed by the residential and commercial sectors. Approximately 37 percent of the CO<sub>2</sub> emitted in the United States, which accounts for 8 percent of global CO<sub>2</sub> emissions, is attributable to the combustion of coal.

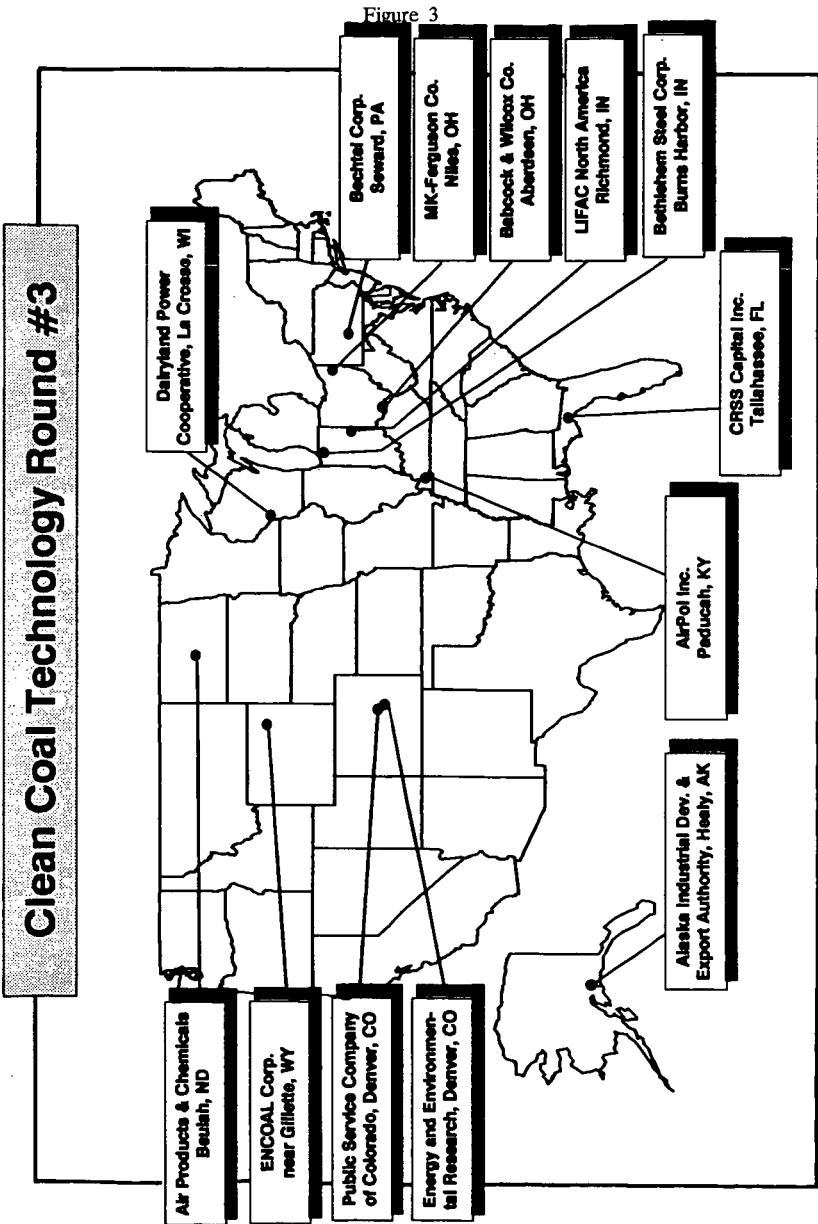


Figure 3



Another greenhouse gas produced by the combustion of fossil fuels is nitrous oxide ( $N_2O$ ), which is a product of both combustion conditions and fuel nitrogen content; recent data suggest that the  $N_2O$  production rate is correlated directly with  $NO_x$  production rates.

CCTs can impact the emissions of greenhouse gases in two fundamental ways: with respect to  $CO_2$ , many of the CCTs improve the efficiency of the conversion of coal to useful energy. Technologies such as pressurized fluidized bed combustion, integrated gasification combined cycle, and fuel cells consume less coal per unit of useful energy produced, thus lowering the amount of  $CO_2$  emitted. Furthermore, these repowering technologies in addition to low  $NO_x$  burners, selective catalytic reduction, and other  $NO_x$  reduction technologies, will reduce  $NO_x$  emissions, which should in turn result in  $N_2O$  emissions reductions. For example, gas reburning technology reduces  $NO_x$  emissions by up to 60 percent, and can reduce  $CO_2$  emissions from 5-10 percent since combustion of natural gas produces less  $CO_2$  than coal combustion.

It is not unexpected that reductions of greenhouse gases emissions will become more common as an international policy objective, and the worldwide commercial deployment of clean coal technologies will take on commensurately added significance.

### **The Clean Air Act Amendments of 1989**

On June 12, 1989, President Bush fulfilled a major campaign commitment by proposing a comprehensive program to provide clean air for all Americans. The President's plan, known as *The Clean Air Act Amendments of 1989* and formally proposed to the Congress on July 21, 1989, called for the first sweeping revisions to the Clean Air Act since 1977, and represented the first time an Administration had put forward a proposal since that time. The President's plan was designed to curb three major threats to the Nation's environment and to the health of millions of Americans: acid rain, urban air pollution, and toxic air emissions.

Five goals underlied the President's clean air proposals and the means for accomplishing them:

- ▶ **Protecting the Public's Health.** To prevent public exposure to cancer-causing agents and to protect those who live in cities with dirty air that does not conform to National health standards.
- ▶ **Improving the Quality of Life.** To improve the quality of life for all Americans by exercising responsible stewardship over the environment for future generations.
- ▶ **Achieving Early Reductions and Steady Progress.** Established realistic timetables to meet air quality standards, but cut substantial amounts of air pollution in the near term, while requiring steady reductions of harder to control emissions.

- ▶ **Harnessing the Power of the Marketplace.** The use of marketable permits to achieve acid rain reductions, and emissions trading to achieve reductions from automobile pollution, so as to clean the air to a definite standard while minimizing the burden on the American economy.
- ▶ **Employing Innovative Technologies.** Encouraged development of Clean Coal Technology, alternative fuel systems for automobiles, and other cost-effective means of using new technology to cut pollution.

The "Acid Deposition Control" (Title V) provisions of the President's bill, with emphasis on those aspects of greatest interest to the CCT Program, are highlighted below:

- A reduction of 10 million tons of SO<sub>2</sub> by the year 2000, using a baseline year of 1980 for tons of SO<sub>2</sub> emitted, primarily from coal-fired power plants.
- A two-phase program in order to ensure early reductions. A reduction of five million tons was required during the first phase, by the end of 1995. (All dates had assumed enactment of this legislation by December 31, 1989.)
- A 2 million ton reduction of NO<sub>x</sub> in Phase II. The plan would have allowed utilities to trade reductions of NO<sub>x</sub> for reductions of SO<sub>2</sub> and vice versa, and thus represented a call for a total reduction of 12 million tons in acid rain-causing pollutants.
- A 3-year extension of the Phase II deadline for plants adopting CCT repowering technologies, combined with regulatory incentives designed to smooth their transition into the marketplace. This would allow the United States to "make good" on the major investment in the CCT Program that the President has called for, and would ensure that coal continues to play an important role in America's energy future.
- Freedom of choice in cutting pollution. The plan required all plants above a certain size in affected States to meet the same emissions standard, but did not dictate to plant managers how the standard should be met. The plan required the largest polluting plants to make the greatest cuts in pollution. The emissions standard would be set at the rate necessary to achieve 5 million tons in the first phase. The plan envisioned a standard of 2.5 lb SO<sub>2</sub>/million Btu, which would affect 107 plants in 18 states. The standard would subsequently be tightened to approximately 1.2 lb/million Btu so as to achieve a 10 million ton reduction of SO<sub>2</sub> in Phase II.

- Maximum flexibility in obtaining reductions. The plan allowed utilities to trade required emissions reductions so that they would be achieved in the most optimal manner. In the first phase, trading would be allowed among electric plants within a State or within a utility system. In addition, full interstate trading would be allowed in Phase II.
- The estimated cost of the President's proposal would have been about \$700 million per year in the first phase, and \$3.8 billion annually in the second phase. While this represents an increase of over 2 percent by the year 2000 in the Nation's \$160 billion a year electricity bill, the flexibility built into the President's plan reduced, by up to half, the cost of various competing proposals mandating the use of specific technologies.

One important provision in the proposed bill, Section 508, "Repowered Sources," established the availability of a 3-year extension of the stage II compliance date (i.e., until the end of 2003, instead of 2000) for *any unit being repowered with one of the following CCTs:*

- ◆ Atmospheric (AFB) or Pressurized Fluidized Bed (PFB) Combustion
- ◆ Integrated Gasification Combined Cycle (IGCC)
- ◆ Magnetohydrodynamics
- ◆ Direct and indirect coal-fired turbines
- ◆ Integrated gasification fuel cells
- ◆ or a "derivative of one of these technologies, as determined by the Administrator of the Environmental Protection Agency (EPA), in consultation with the Secretary of Energy."

Such a repowered source would be exempt from meeting EPA New Source Performance Standards (NSPS) for SO<sub>2</sub> and would benefit from streamlined New Source Review (NSR) procedures if their potential emissions were expected to increase.

Section 515 of the bill, entitled, "Clean Coal Technology Regulatory Incentives," also was very important to the CCT Program. Here, CCTs were defined as:

any technology, including technologies applied at the precombustion, combustion, or postcombustion stage, at a new or existing facility which will achieve significant reductions in air emissions of SO<sub>2</sub> or NO<sub>x</sub> associated with the utilization of coal in the generation of electricity, process steam, or industrial products, which is not in widespread use as of the date of enactment of this title.

In order to encourage the use of such CCTs, the Federal Energy Regulatory Commission (FERC) was required here to adopt regulations for a 5-year CCT demonstration program that would include establishment of an incentive rate of return and a 10- to 20-year amortization period. This proposal also required FERC to develop a process whereby it would negotiate a prudent level of investment for CCTs and other "innovative emission control technology."

This Section also exempted temporary and permanent CCT demonstration projects from NSR requirements under Section 111 (*Standards of Performance for New Stationary Sources*) and Parts C (*Prevention of Significant Deterioration of Air Quality*) and D (*[State Implementation] Plan Requirements for Nonattainment Areas*) of the current Clean Air Act, so long as the demonstration project would not increase the original facility's potential to emit any pollutant regulated under the Act.

Finally, States were encouraged to provide additional utility regulatory incentives for the promotion of CCTs, and several examples were provided.

### **The CCT Program and National Energy Strategy**

On July 26, 1989, the Secretary of Energy, Admiral James D. Watkins, appeared before the Senate Committee on Energy and Natural Resources to discuss the President's plan for development of a National Energy Strategy (NES). In his opening remarks, the Secretary noted that:

Environmental concerns are putting new pressures on our ability to use our most abundant domestic fuel, coal. Electricity reserve margins are shrinking across the country. Voltage reductions have already been required in the Northeast, and right here in Washington. Meanwhile, New York State officials are rushing to pull fuel rods from a completed, safe nuclear power plant. ... Our country needs a clear energy blueprint to take the United States into the next century — a National Energy Strategy.

The President has directed me to lead the development of this National Energy Strategy — an action plan essential to providing this Nation, in the years to come, with adequate supplies of competitively priced, clean energy. This strategy will serve as a blueprint for energy policy and government program decisions. It will contain specific short-term, mid-term,

and long-term recommendations. This strategy will chart our course, set our pace, and provide mileposts by which to evaluate our progress in providing the energy our economy needs, while protecting the Nation's health, safety, and environment.

... I have committed the Department to extensive consultations with the Governors and State officials of this Nation, with Congress, with industry, and with the American people.

The Secretary observed that, "If the National Energy Strategy is to gain the support of the American people, it must be built on a reliable foundation of data, analytical tools, and forecasting capability." Accordingly, he has instructed DOE to work closely with the Energy Information Administration to develop a National Energy Modeling System (NEMS); he has also asked the National Academy of Sciences "to examine our plans for the development of the NEMS and ensure that it will, to the maximum extent possible, address the critical energy issues before us. These include major environmental issues, strategic considerations and technology research and development."

The goals of the CCT Program are germane to and supportive of many of the recurring themes in the NES development process. For example, the National Laboratories were asked to assist DOE with the analyses of key issues and the preparation of special white papers, completed this past autumn, on such subjects as:

- The science of global climate change and the scope of uncertainty. This subject area encompasses CO<sub>2</sub> releases, and pertains to the increased efficiency of some of the CCTs, with attendant reduced emissions.
- Options available to enhance DOE technology transfer to the broader development community. Technology transfer is important not only to meet National energy and environmental objectives, but to assure that lesser developed nations — which are the fastest growing energy users — will do the same.

The subject of technology transfer is "near and dear" to the CCT Program, which considers this activity as vital to the promulgation and deployment of mature CCTs into the marketplace, both home and abroad. We believe that CCTs offer the opportunity for export of U.S. coal together with the know-how to consume it cleanly and cost-effectively to the mutual benefit of both the consumers and the vendors.

On April 2, 1990, the Secretary of Energy announced the completion of the first phase — information gathering — of the development of the NES, and released for public comment the *Interim Report on the Development of a National Energy Strategy, A Compilation of Public Comment*. The Secretary noted that the report "will provide a baseline for for development and analysis of energy options, and public comment on the report is invited." As was noted in the accompanying News Release, since August 1989, DOE has held 15 public hearings, received more than one thousand written submissions, and compiled twelve thousand pages of public hearing record. The *Interim Report* conveys the results of that public participation, presenting a compendium of public concern, and a series of publicly identified goals, obstacles to progress, and options for overcoming them.

This was followed almost immediately by the announcement on April 12, 1990, of the completion and release for review by the public of five National Laboratory "white papers" that had been commissioned by DOE to assist in the development of the NES:

- ▶ *Energy Efficiency: How Far Can We Go?*
- ▶ *The Potential of Renewable Energy.*
- ▶ *Energy and Climate Change.*
- ▶ *Energy Technology for Developing Countries.*
- ▶ *The Technology Transfer Process.*

Finally, some of the remarks about CCTs and the CCT Program, that were offered by panelists in the course of discussing the NES, are noteworthy, as follows:

Clean coal program of DOE is important for removing constraints to coal use, given current old technology and environmental concerns.

- **State government official**

Energy and environmental policy should be coordinated. Clean coal technology to reduce NO<sub>x</sub> and SO<sub>2</sub> emissions is good example.

- **Public utilities commissioner**

Coal is the largest domestic resource, however its viability as an energy source is seriously constrained by air quality regulations and cost of compliance; by the need for federal support of clean coal technology development; and proposed acid rain legislation capping SO<sub>2</sub> and NO<sub>x</sub> emissions.

- **Electric utility executive**

Coal is the most plentiful resource but is underutilized; energy research on effective and clean use of coal is needed ... Promotion of coal exports should be undertaken, and clean coal technology should be promoted.

- Energy company executive

Clean coal program R&D is now addressing containment of CO<sub>2</sub> emissions ... Progress being made in environmental protection is not being communicated to the public. Public information program is needed as part of the strategy of NES to inform public on environmental health and safety.

- Coal company executive

### **The Future; CCT-IV and -V**

On October 23, 1989, President Bush signed Public Law No. 101-121, "Department of the Interior and Related Agencies Appropriations, Fiscal Year 1990." Among other things, this Bill provided \$1.2 billion for the 4th and 5th rounds of CCT solicitations (\$600 million for each in FY 1991 and FY 1992), and specified dates for release of the solicitations, submittal of proposals, and selections of projects.

The language in the accompanying Conference Report (No. 101-264) included the guidance that the word "replacing" should be added to the definition of "clean coal technology," and noted that:

... the inclusion of "replacing" for clean coal IV and V is intended to cover the complete replacement of an existing facility if, because of design or site specific limitations, repowering or retrofitting of the plant is not a desirable option.

Although the original schedule called for release of the CCT-IV solicitation on or before June 1, 1990, on May 15, 1990, DOE announced that it intended to delay issuance of the solicitation "until uncertainties regarding Congressional action have been resolved." The News Release of that date noted that the Secretary of Energy had "informed Congress that unresolved issues in the pending Supplemental Appropriations Act and the Clean Air Act Amendments make it premature for the Energy Department to begin asking industry for new CCT proposals." The Release also pointed out that this delay will provide time for a draft of the solicitation to be issued for public comment prior to its official release. It is anticipated that, with the passage of the Clean Air Bill, PON-IV, revised as appropriate to accommodate the provisions of the Bill, will be released.

